# Prediction and Forecasting of Maximum Weather Temperature Using a Linear Autoregressive Model



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**Abstract.** This paper investigates the autoregressive (AR) model performance in prediction and forecasting the monthly maximum temperature. The temperature recordings are collected over 12 years (i.e., 144 monthly readings). All the data are stationaries, which is converted to be stationary, via obtaining the normal logarithm values. The recordings are then divided into 70% training and 30% testing sample. The training sample is used for determining the structure of the AR model while the testing sample is used for validating the obtained model in forecasting performance. A wide range of model order is selected and the most suitable order is selected in terms of the highest modelling accuracy. The study shows that the monthly maximum temperature can accurately be predicted and forecasted using the AR model.

**Keywords:** Autoregressive Model; Baghdad City; prediction model; temperature.

## 1. Introduction

Climate change and climate variability are anticipated to cause significant issues for the ecosystem (i.e., increase the temperature in future) [1, 2]. Industrialisation and the massive use of fossil fuels caused an increase the greenhouse gases that led to an increase in the impact of climate change [3, 4]. It has located a substantial impact on the environment of residential area in various places of the world [5-7]. These influences differ concerning the region, the type, and the importance.

The climatic factors have impacted, directly and indirectly, both individuals and their residential environment along different periods [8]. Temperature is considered the most vital climatic factor, which impacts the growth, development and yield of crops [9]. Additionally, the system of dwellings is developed in response to climatic factors [10, 11].

Different regions face a harmful influence of climate change that led to decreasing the quantity[12-16] and quality [17-22] of freshwater resources. High temperatures (i.e., dry day) lead to increase urban water consumption [23]. Additionally, various studies showed that urban water consumption was driven by maximum temperature [24-28].

In the last few years, precise forecast of temperature is a problem which has attracted the researchers' attention, since it has several various applications in the field such as industry, agriculture or energy. Recently, different models are used in different areas [29-33], and studies forecast the maximum temperature by various techniques [34-36]. The AR model used successfully in different applications [37-39]. In this research, Auto-regressive (AR) model will employ to predict the monthly temperature.

## 2. Area of study and data set

Iraq is one of the Arab countries that lies in arid to the semi-arid area, and Baghdad is the capital of Iraq and locates in the centre of the country[40]. The weather is wet and cold in winter and dry and hot in summer (i.e., the temperature reaches 45 $^{o}$C). Iraq faced an acute climate change cased adversely impact the people, residential area, and freshwater sources[41-43]. The historical monthly data if maximum temperature along twelve years (2003-3014) used to build and assess the model.

## 3. Methodology

The procedure of this research divides into, data pre-processing, and auto-regressive model.

### *3.1. Data Pre-processing*

It has a considerable influence on the accuracy of the forecast techniques. It can be separated here into two phases: normalisation and cleaning. Normalisation time series assistances to decrease the impact of outliers and makes the data to be normal or near-normal distribution [44, 45]. In this research, a natural logarithm is used for normalising the data due to its ability to decrease the influence of multicollinearity among predictor factors[28, 46].

### *3.2. Auto-Regressive Model (AR)*

In autoregressive (AR) model, the output pertaining to a particular variable can be predicted from the past observations of that variable[47]. This model has a linear form. As such, the simplicity of this model coupled with its powerful prediction increases the popularity of this model in different disciplines in which time series data need to be analysed. In water demand forecasting, city engineers and water authorities are working collectively to maintain the balance between the demand and supply of drinking water to residents in their city. Hence, to achieve this goal, a sound statistical method should be used. Accordingly, there is a growing interest in applying autoregressive model in water demand forecasting. The outputs in this model are merely dependent on the previous observations of the same variable [37, 38].

To mathematically formulate autoregressive models, Eq. (1) is used to relate the current observation with the past ones in a linear relationship as illustrated:

$$X_t = \theta_0 + \sum_{i=1}^{p} k_i X_{t-1} + \varepsilon_t \quad (1)$$

Where; $X_t$ and $X_{t-1}$ are the observations in periods *t* and *t-1*, p is the order of the AR model considered, $k_i$ is the autoregressive parameters, $\theta_0$ is the constant term, and $\varepsilon_t$ is the disturbance term for period *t.* A least-square algorithm using MATLAB is utilized to accurately predict the unknown coefficients in the AR model.

## 4. Results and discussion

Data were normalised, cleaned and divided into two sets training (70%) and testing (30%). Figure 1 shows various model goodness of fit for both training and testing sample. These models of fitness are

obtained in different model order. As it was mentioned earlier that the training sample was used for obtaining the AR model coefficients while the testing sample is used for evaluating the forecasting capability of the model. The model goodness of fit contains coefficients of regression(R), mean absolute error (MAE), mean square error (MSE), and root mean square error (RMSE). From all the curves of the model goodness of fit, it is clear that the best model order is 10.

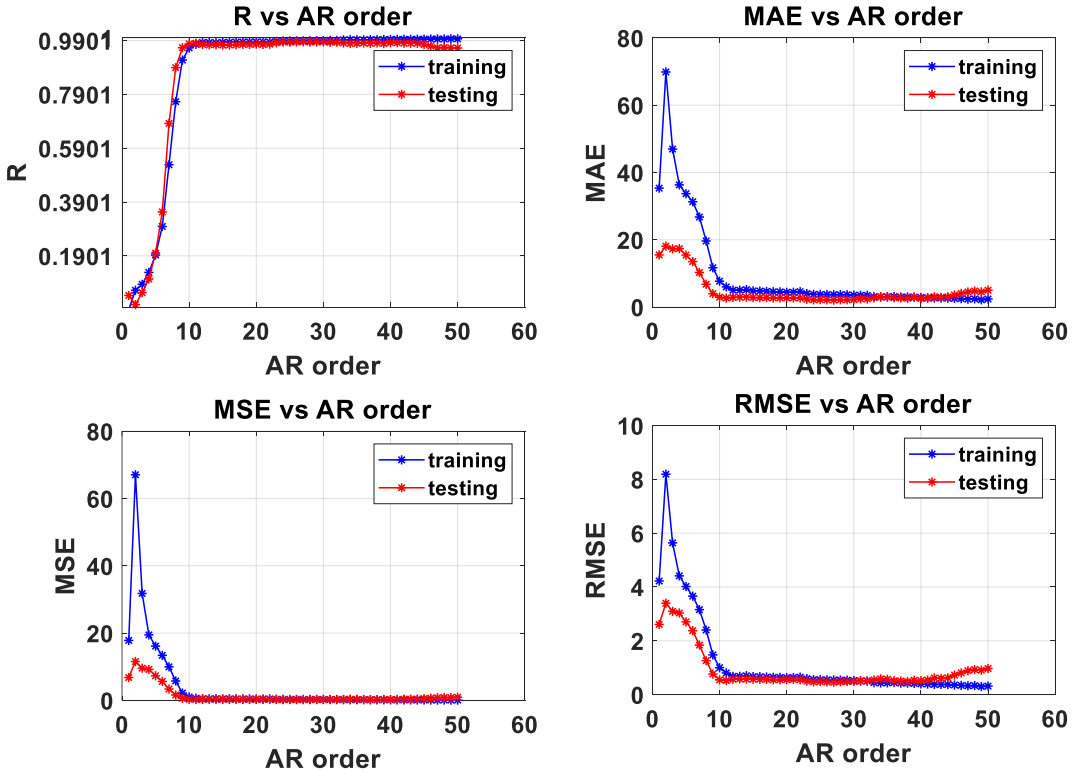


**Figure 1.** Assess the performance of the AR model by four goodness of fit.

Additionally, the graphical test is used to examine the performance of AR model. Figure 2 visualises the model forecasting performance. It shows the real measure temperature as well as the forecasted ones in the testing stage.

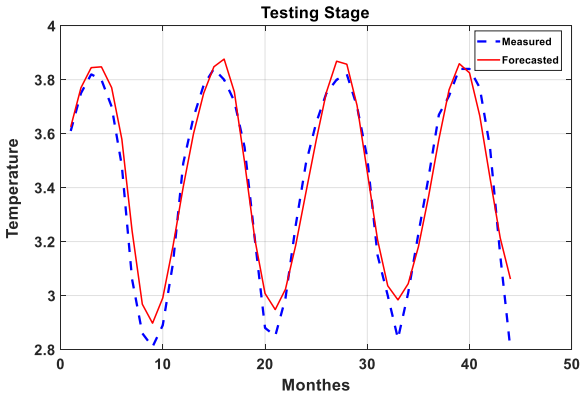

**Figure 2.** Measured and forecasted temperature.

Moreover, coefficient of determination is employed to assess the performance of AR model to forecast the monthly temperature. Figure 3 shows that the value of $R^2$ is 0.96, which means that the performance of AR model is good according to the Dawson et al., [48].

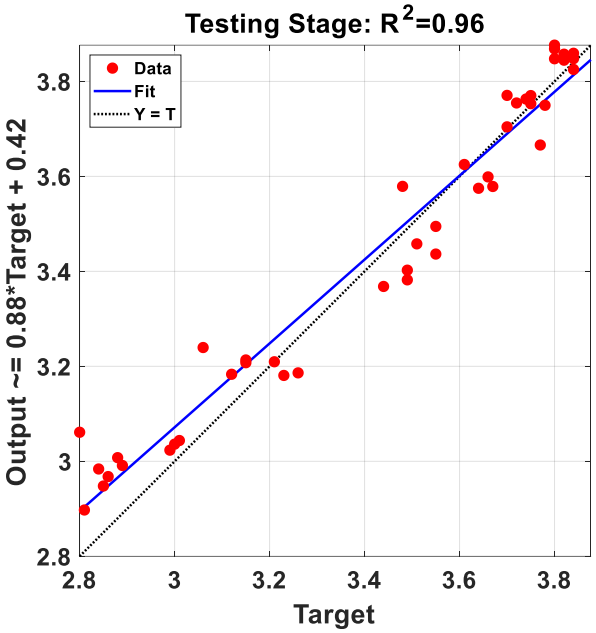


**Figure 3.** AR model performance.

Based on the above statistical tests, it reveals that this methodology is able to forecast the maximum temperature.

## 5. Conclusion

This research examines the performance of a method to predict and simulate the monthly maximum temperature. Monthly time series of historical maximum temperature for Baghdad City along twelve years (2003-2014) were used for building and assessing the suggested practice. The method contains data pre-processing and AR model. Data were divided into training (70%) and testing (30%). Different statistical tests were used to examine the methodology. The results show that the methodology forecast the data with good accuracy in the testing stage with $R^2$ equal to 0.96. Extra research should be conducted concerning forecast maximum temperature for the rest cities in Iraq.

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